

Please add new claims 23 as follows:

~~1-23. The method of claim 22 wherein said non-oxidizing atmosphere is a nitrogen atmosphere.~~

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REMARKS

The Office Action of September 3, 1996 was received and carefully reviewed. By this Amendment, Applicants respond to each of the objections and rejections set forth in the Office Action. Reconsideration and withdrawal of the currently pending rejections are now respectfully requested.

Claims 1, 2, 6, 10, 11, 14, 17, 21 and 22 are amended, and new claim 23 is added herein to complete the scope of protection to which Applicants are entitled. Consequently, claims 1-4, 6-15 and 17-23 are currently pending in the instant application.

Initially, addressing the formal objections and rejections set forth in the Office Action, claim 10 is rejected under 35 U.S.C. §112, second paragraph, for being indefinite. In view thereof, claim 10 is amended herein to recite that the crystalline silicon film is maintained at 450-600°C during the irradiating step. Support for this during the irradiation step is provided on page 20, lines 25-27.

The disclosure is also objected to for informalities on page 12 regarding Figure 8. In view thereof, Figure 8 is amended in the attached *Request for Drawing Change Approval* to comport with the terminology of the specification. The Examiner's authorization of these drawings changes are respectfully requested.

With regard to paragraph 17 of the Office Action, claims 1-4 do not recite the addition of a catalyst or a metal as the Examiner insists.

However, independent claims 1 and 2 do recite technical features which indicate decreasing spin density under a nitrogen atmosphere, and the numbers of dangling bonds under a non-oxidizing atmosphere, respectively. As provided below, these features of the present invention distinguish the present invention over the cited art of record.

Specifically, the present invention is directed to a method comprising the steps of introducing a catalyst capable of promoting crystallization of amorphous silicon into an amorphous silicon film; crystallizing the amorphous silicon film by irradiating with a laser light; heating the crystallized silicon film in a nitrogen or non-oxidizing atmosphere to decrease a spin density and dangling bonds in the crystallized silicon film. The instant application relates to technical features which differ from the references cited by the Examiner as follows.

Claims 1-4 are rejected by Takemura U.S. Patent No. 5,403,762 under 35 U.S.C. §102(e) and the judicially created doctrine of obviousness-type double patenting. The Examiner indicates Takemura discloses alternative laser irradiation and thermal annealing techniques. However, these treatments of Takemura are performed for activation of the impurities while those of the present invention are for crystallizing a silicon film.

Takemura also discloses recrystallization of the silicon film by irradiating with a laser light since the silicon film is damaged during implantation of Si. The object of irradiation with a laser light is different from that of the instant invention because the purpose of irradiating is crystallizing amorphous silicon in the present application. Further, Takemura indicates laser treatment with subsequent annealing at 350°C for two hours in H₂. However, thermal annealing after the laser treatment of the present invention is performed in a nitrogen atmosphere. Consequently,

the disclosed and recited features of Takemura are different from those of the present invention, and, thus, Applicants contend that claims 1-4 should be considered distinguishable thereover.

Claims 1-4 are also rejected under 35 U.S.C. §102(e) as being anticipated by Zhang et al. This rejection is also traversed for the reasons advanced below.

Zhang U.S. Patent No. 5,529,937 discloses both thermal and radiation treatment. These treatments are performed after patterning a silicon film (Fig. 1(C)), while irradiating and heating are performed before patterning process in the present application. Further, Zhang discloses heating of the entire substrate from 300-500°C in an oxygen atmosphere so that a silicon oxide film is formed.

In the case of the present invention, however, a substrate is heated under a nitrogen atmosphere so as to decrease spin density in a crystallized silicon film. The claims of the instant application are amended to recite that the crystallization step is conducted in a nitrogen or non-oxidizing atmosphere to decrease dangling bonds and spin density in the resulting silicon film. This is not disclosed or suggested by the Zhang reference.

Claims 1-4 are further rejected under 35 U.S.C. §102(b) as anticipated by Fan et al. The Examiner indicates Fan U.S. Patent No. 4,309,225 discloses crystallization of amorphous silicon with a laser light under Ar/H₂ atmosphere so that the dangling bonds would be inherently being neutralized.

The present invention, on the other hand, discloses heat treatment in a nitrogen atmosphere in order to decrease spin density in a crystallized silicon film. Moreover, as noted by the Examiner, Fan indicates using a metal layer of Cu, Ag, Sn, Au or other metals. The metal layer of Fan is

formed as a conductive layer while a metal of the instant invention is added into silicon film as a catalyst being capable for promoting crystallization of amorphous silicon. Consequently, claims 1-4 should be considered distinguishable over Fan et al.

Claims 1-4 are rejected under 35 U.S.C. §102(b) as being anticipated by Celler U.S. Patent No. 4,249,962. Celler is alleged to disclose laser recrystallization step and subsequent heating step, as well as impurities such as Cu, Ni, Fe, and Au. However, Celler does not indicate using these metals as catalyst. Celler also does not appear to disclose the crystallization of a silicon film in a nitrogen or non-oxidizing atmosphere. Consequently, this rejection should likewise be overcome.

Claims 6-15 and 17-22 are rejected under 35 U.S.C. §103 over Fan or Celler as applied to claims 1-4 above and further in view of Hample or Hayzelden and in view of Pressley U.S. Patent No. 4,415,373.

Hayzelden and Hample are alleged to disclose amorphous silicon with ion implanted or co-sputtered nickel, respectively. Pressley is alleged to indicate to getter defects by metallic elemental impurities. However, the advantage of this present invention is being capable to obtain a crystallized silicon film with high crystallinity by introducing nickel which promotes crystallization of amorphous silicon. The silicon film is then irradiated with a laser to crystallize the film using the catalyst elements to promote crystallization, followed by a thermal annealing step in a nitrogen or non-oxidizing atmosphere to decrease spin density in the crystallized silicon. The cited references do not appear to disclose such a process, and, thus, claims 6-15 and 17-22 should be overcome the cited references.

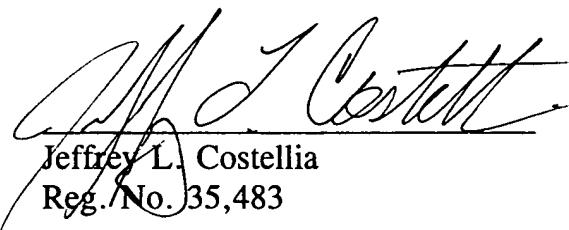
Because of the features of the present application as described, Applicants contend that the claimed invention is also patentably distinct over

Imahashi U.S. Patent No. 5,372,836, Moddel U.S. Patent No. 4,539,431, Togei U.S. Patent No. 4,292,091, Liu U.S. Patent No. 5,147,926, Fonash U.S. Patent No. 5,275,851, Pankove U.S. Patent No. 4,322,253, Zhang U.S. Patent No. 5,352,291 and Takayama U.S. Patent No. 5,501,989.

New claim 23 is added to depend from claim 22 to specifically recite that the non-oxidizing gas is nitrogen.

In view of the foregoing, it is respectfully requested that the rejections of record be reconsidered and withdrawn by the Examiner, that claims 1-4, 6-15 and 17-22 be allowed, that new claim 23 be allowed and that the application be passed to issue. If the Examiner believes a conference would be of benefit in expediting the prosecution of the instant application, she is hereby invited to telephone counsel to arrange such a conference.

Respectfully submitted,



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